Carbonated basalts at depth: density, compression mechanisms, and potential buoyancy

C. SANLOUP[1*], C. CRÉPISSON[2], G. MORARD[3], H. BUREAU[3], G. PROUTEAU[4] AND S. PETITGIRARD[5]

[1]University of Edinburgh, Edinburgh, UK, chrystele.sanloup@ed.ac.uk (* presenting author)
[2]Ecole Normale Supérieure, Paris, France, celine.crepisson@ens.fr
[3]Université Pierre et Marie Curie – Paris 6, Paris, France
[4]ISTO, Orléans, France
[5]European Synchrotron Radiation Facility, Grenoble, France

Introduction

The alkali basalt composition was chosen as representative of two potentially relevant contexts : alkali basalts dragged in the Japanese sea have been interpreted as originating from the asthenosphere [1,2], and their high vesicularity suggested high CO_2 content in the pre-eruptive melt. Also, primitive alkali basalts are generated in subduction contexts, as the one used here (Stromboli [3]) and as such, could have contributed to the formation of cratonic roots.

Experiments

In situ density and structural measurements were collected using respectively x-ray absorption and x-ray diffraction techniques. High P-T conditions up to 7 GPa were generated using the Paris-Edinburgh press at the european synchrotron (ESRF, ID27 beamline) and the cell-assembly described in [5]. Recovered quenched samples were analyzed by EPMA and Raman spectroscopy to check for CO_2 content and speciation.

Density measurements as a function of pressure show a higher compressibility than for non-carbonated basalts. Structural data, as expressed by pair distribution function of the melt, show an increased coordination number of Al. Such effect had been proposed based on viscosity measurements at modest P [6,7], and seems emphasized at higher P.

Density of the carbonated alkali basalt is then compared to seismological and petrological values of the density for surrounding rocks to check for potential neutral buoyancy at depth.

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Interpretation of helium isotopes in modern hydrothermal systems

Y. SANO[1] AND T. P. FISCHER[2, 3]

[1]Atmosphere and Ocean Research Institute, University of Tokyo, Kashiwanoha, Chiba 277-8564, Japan (*correspondence: ysano@aori.u-tokyo.ac.jp)
[2]Division of Earth Sciences, National Science Foundation, Arlington, VA 22230, USA
[3]Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM87131-1116, USA

Many reviews and textbooks on terrestrial helium isotopes have been published since the discovery of mantle helium in 1969. This work focuses on the interpretation of helium isotopes of fluid samples in modern hydrothermal systems. In hot spot regions such as Hawaii, Yellowstone and Iceland, helium isotopes of fluid samples are generally higher than MORB-type He (8.0+/-1.5) Ra where Ra is the atmospheric ratio of $1.4x10^{-6}$. Seismic tomography data of the three regions show that a continuous low-velocity anomaly is imaged from the surface to at least the surface of the lower mantle [1-3]. The plume-type He may be derived from the lower mantle. In the other hot spot regions such as Afar, Canary and Reunion, the thermal conduit associated with mantle upwelling extends to depths greater than 500 km. There is a weak positive correlation between maximum helium isotopes and the buoyance flux except for Hawaii. Graham [4] compiled 658 MORB glass data and reported that the more than 90% of helium isotopes are lying between 6.5-9.5 Ra. Hydrothermal fluids in MOR shows the helium isotopes varying from 7.2 Ra to 9.2 Ra with the average of (8.09+/-0.49) Ra, identical to that of the global average of MORB. The average ^{3}He/heat ratios is calculated (8.6+/-3.8) x 10^{-18} mol/J world-wide. When we take into account of a global axial heat flow in MOR [5], the total ^{3}He flux would become (2.8+/-1.2) atom/cm^2/s, a little smaller than the well-established value of 4 atom/cm^2/s [6]. Helium isotope data of subduction zones were compiled by Hilton et al [7]. Now additional data are available in the Kamchatka, Izu-Bonin, Ryukyu-Taiwan, Sangihe arc in Indonesia and Central American system. The cir-cum Pacific helium data are summarized as follows: (a) helium isotopes vary significantly from 0.01 Ra to 10.1 Ra and the rage is much larger than that of MOR-type He. (b) The highest value of 10.1 Ra observed in the Vanuatu islands suggests the contribution of plume-type He. (c) The second highest values (8.8-8.9) Ra are found in the Colombian Andes and Sunda arc systems, falling within the range of MOR-type He. (d) Relatively lower values (6.5–7.0) Ra are observed in the Ecuadorian, Peruvian and Chilean Andes and the eastern Sunda/Banda arc, slightly lower than that of MOR-type. There is no apparent correlation between the maximum value of arc segments and the magma production rate or the taper angle of the slab.

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